Building a Bridge to the Corn Ethanol Industry:
Corn Fiber Conversion in the Ethanol Industry

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Objective: This subcontract addressed a study to generalize the combined results and experience to fiber processing to ethanol in the industry. This study carried out a design of a corn-fiber process based on aqueous pretreatment of the fiber; fermentation of either hexoses, or hexose and pentoses to ethanol; and disposition of the remaining proteins and other streams resulting from such a process. Equipment design and process economics were specified for an enzyme-based hydrolysis process using the throughputs associated with a wet-milling plant that currently is based on a design rate of 108 million gallons ethanol/year or 120,000 bushels corn/day.

Approach/Background: The Department of Energy's Office of Fuels Development (OFD) recognizes the leadership potential of the existing grain processing industry, and the ability of the industry to lead commercialization of biomass to sugars and ethanol. Additions to an existing ethanol plant or other sites with compatible processes may reduce capital and operating cost, and existing process and operational infrastructure may be able to support increased operations and reduce the cost of sugar and ethanol production.

A three-way cooperative effort was initiated between Purdue University, Pekin Energy (now Williams Energy Services), and USDA NCAUR. This effort has performed preliminary tests of new technology for pretreating the corn fiber by pressure cooking it in water, followed by hydrolysis and pentose fermentation. The cooperative research demonstrated the viability of fiber pretreatment through pilot plant runs, and the

fermentability of the resulting hexoses and pentoses to ethanol by a recombinant microorganism.

Status/Accomplishments: Key elements of the process were tested in the laboratory or pilot plant in order to confirm validity of key design assumptions. These results and the pro-forma results indicate areas for further testing, in preparation of building a 1/9-scale unit. A key issue will be the materials handling properties of the corn fiber system, and the type of equipment, which might be needed to handle it. Integration of the equipment in the way that compliments other unit operations and the material flows are addressed in the process diagrams. The flow diagram, and utility requirements are based on equipment quotations from vendors and Pekin's operating experience.

Economic analysis of the conversion by pretreatment of corn fiber to ethanol has been carried out, and using the current technology has been shown to be an economically viable process. The price per gallon of converting corn fiber to ethanol by this method, which would be practical for an operating corn wet-milling ethanol plant, has been calculated to be between $0.77 and $0.87/gallon. The cost of corn stover conversion is much higher if the resale value of solids that remain after pretreatment and hydrolysis is assumed to be zero. If the resale value of remaining solids is equivalent to their wet combustion value, the cost for corn stover conversion is in the range of $1.04 to $1.23/gallon, when the corn stover is processed within the battery limits of a wet-milling plant.

Fermentation of xylose for both the fiber and corn stover cases will reduce ethanol costs. Costs for corn fiber with xylose fermentation will be in the range of $0.74 to 0.83/gallon. Costs for corn stover would be $0.67 to $0.80/gallon. If the arabinose is fermented, in addition to the xylose, ethanol costs would be $0.72 to $0.80/gallon for fiber and $0.64 to 0.77/gallon for corn stover.

The take-home messages from our pro-forma analysis is that:

(1) Corn fiber conversion to ethanol based only on fermentation of glucose hydrolysate approaches an economically interesting range.
(2) Corn fiber conversion based on fermentation of glucose and xylose makes the costs even more attractive.
(3) Co-product credits for corn stover are essential to attain a cost of less than $1.00/gallon.
(4) Fermentation of both glucose and xylose will make corn stover an economically attractive substrate for an existing wet-milling plant.

Publications and Presentations:

Saha, B.C. and R.J. Bothast "Pretreatment and Enzymatic Saccharification of Corn Fiber" Applied Biochemistry and Biotechnology, **76**, 65-77. (1999)

Kaar, W.E. and M.T. Holtzapple "Benefits from Tween During Enzymatic Hydrolysis of Corn Stover" Biotechnology and Bioengineering, **59** (4), 419-427. (1998)

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